

04-24-2000

EL46568 2905

PTO/SB/05 (4/98)

Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCEPlease type a plus sign (+) inside this box → ☐

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**UTILITY
PATENT APPLICATION
TRANSMITTAL**

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	MI 22-1422
First Inventor or Application Identifier	Scott E. Moore et al.
Title	See 1 in Addendum
Express Mail Label No.	EL 465682905US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. ☒ * Fee Transmittal Form (e.g., PTO/SB/17)
(Submit an original and a duplicate for fee processing)
2. ☒ Specification [Total Pages (preferred arrangement set forth below)
- Descriptive title of the Invention
 - Cross References to Related Applications
 - Statement Regarding Fed sponsored R & D
 - Reference to Microfiche Appendix
 - Background of the Invention
 - Brief Summary of the Invention
 - Brief Description of the Drawings (if filed)
 - Detailed Description
 - Claim(s)
 - Abstract of the Disclosure
3. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets

4. Oath or Declaration [Total Pages
 - a. ☐ Newly executed (original or copy)
 - b. ☒ Copy from a prior application (37 C.F.R. § 1.63(d))
(for continuation/divisional with Box 16 completed)
 - i. ☐ DELETION OF INVENTOR(S)
Signed statement attached deleting
inventor(s) named in the prior application,
see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

5. ☐ Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
- a. ☐ Computer Readable Copy
 - b. ☐ Paper Copy (identical to computer copy)
 - c. ☐ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. ☐ Assignment Papers (cover sheet & document(s))
8. ☐ 37 C.F.R. § 3.73(b) Statement ☐ Power of
(when there is an assignee) ☐ Attorney
9. ☐ English Translation Document (if applicable)
10. ☒ Information Disclosure ☐ Copies of IDS
Statement (IDS)/PTO-1449 ☐ Citations
11. ☒ Preliminary Amendment
12. ☒ Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)
13. ☐ * Small Entity ☐ Statement filed in prior application
Statement(s) ☐ Status still proper and desired
(PTO/SB/09-12)
14. ☐ Certified Copy of Priority Document(s)
(if foreign priority is claimed)
15. ☒ Other: Check for \$690.00

**NOTE FOR ITEMS 1 & 13 IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY
FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT
IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).****16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:**

☐ Continuation ☒ Divisional ☐ Continuation-in-part (CIP) of prior application No: 09/324,737
Prior application information: Examiner W. Berry Group / Art Unit: 3723

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS☒ Customer Number or Bar Code Label

021567

or ☐ Correspondence address below

(Insert Customer No. or Attach bar code label here)

Name

Address

City

State

Zip Code

Country

Telephone

Fax

Name (Print/Type)

James D. Shaurette

Registration No. (Attorney/Agent)

39,833

Signature

Date

4/17/00

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

Addendum

- ## 1. Semiconductor Processors, Sensors, and Semiconductor Processing Systems

General Information		Demographics		Clinical History		Physical Examination		Laboratory Studies		Imaging Studies		Treatment		Outcome			
Field	Value	Field	Value	Field	Value	Field	Value	Field	Value	Field	Value	Field	Value	Field	Value		
Age	65	Sex	Male	Chief Complaint	Intermittent abdominal pain	Weight	75 kg	Temperature	38.5°C	White Blood Count	12,000/mm ³	Abdominal X-ray	Normal	Medication	Analgesics	Response	Partial
Weight	75 kg	Height	175 cm	Duration	3 months	Blood Pressure	120/80 mmHg	Heart Rate	90 bpm	CRP	10 mg/L	CT Scan	Small bowel thickening	Diet	Low fiber	Follow-up	6 weeks
Height	175 cm	Medical History	None	Associated Symptoms	Weight loss	Respiratory Rate	18 breaths/min	Oxygen Saturation	98%	ESR	30 mm/hr	Biopsy	Inflammation	Hydration	Normal	Discharge	Stable
Medical History	None	Family History	None	Previous Treatments	Antibiotics	Physical Activity	Low	Smoking Status	Non-smoker	Stool Studies	Normal	Endoscopy	Normal	Surgery	None	Referral	None
Family History	None	Social History	Alcohol	Current Medications	None	Travel History	None	Occupation	Retired	Immunizations	Up to date	Pathology	Normal	Prognosis	Good	Notes	Continued
Social History	Alcohol	Occupation	Retired	Insurance	Medicare	Current Medications	None	Insurance	Medicare	Referral	None	Notes	Continued	Referral	None	Notes	Continued

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

priority Application Serial No. 09/324,737
priority Filing Date June 3, 1999
 Inventor Scott E. Moore et al.
 Assignee Micron Technology, Inc.
priority Group Art Unit 3723
priority Examiner W. Berry
 Attorney's Docket No. MI22-1422
 Title: Semiconductor Processors, Sensors, and Semiconductor Processing Systems

PRELIMINARY AMENDMENT

To: BOX PATENT APPLICATION
 Assistant Commissioner for Patents
 Washington, D.C. 20231

From: James D. Shaurette (Tel. 509-624-4276; Fax 509-838-3424)
 Wells, St. John, Roberts, Gregory & Matkin P.S.
 601 W. First Avenue, Suite 1300
 Spokane, WA 99201-3828

AMENDMENTS

In the Claims

Please cancel claims 1-35.

REMARKS


This application is a divisional application of U.S. Patent Application Serial No. 09/324,737. Claims 1-35 have been canceled without prejudice. Claims 36-58 remain in the application for consideration.

Respectfully submitted,

Dated:

4/21/00

By:



James D. Shaurette
Reg. No. 39,833

EL46568 2905

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR LETTERS PATENT

* * * * *

SEMICONDUCTOR PROCESSORS, SENSORS,
SEMICONDUCTOR PROCESSING SYSTEMS,
SEMICONDUCTOR WORKPIECE PROCESSING
METHODS, AND TURBIDITY MONITORING
METHODS

* * * * *

INVENTORS

SCOTT E. MOORE
SCOTT G. MEIKLE
MAGDEL CRUM

ATTORNEY'S DOCKET NO. MI22-1145

001240 1649560

1 SEMICONDUCTOR PROCESSORS, SENSORS, SEMICONDUCTOR
2 PROCESSING SYSTEMS, SEMICONDUCTOR WORKPIECE
3 PROCESSING METHODS, AND TURBIDITY MONITORING
4 METHODS

5 TECHNICAL FIELD

6 The present invention relates to semiconductor processors, sensors,
7 semiconductor processing systems, semiconductor workpiece processing
8 methods, and turbidity monitoring methods.

9 BACKGROUND OF THE INVENTION

10 Numerous semiconductor processing tools are typically utilized
11 during the fabrication of semiconductor devices. One such common
12 semiconductor processor is a chemical-mechanical polishing (CMP)
13 processor. A chemical-mechanical polishing processor is typically used
14 to polish or planarize the front face or device side of a semiconductor
15 wafer. Numerous polishing steps utilizing the chemical-mechanical
16 polishing system can be implemented during the fabrication or processing
17 of a single wafer.

18 In an exemplary chemical-mechanical polishing apparatus, a
19 semiconductor wafer is rotated against a rotating polishing pad while an
20 abrasive and chemically reactive solution, also referred to as a slurry,
21 is supplied to the rotating pad. Further details of chemical-mechanical
22 polishing are described in U.S. Patent No. 5,755,614, incorporated herein
23 by reference.
24

1 A number of polishing parameters affect the processing of a
2 semiconductor wafer. Exemplary polishing parameters of a
3 semiconductor wafer include downward pressure upon a semiconductor
4 wafer, rotational speed of a carrier, speed of a polishing pad, flow rate
5 of slurry, and pH of the slurry.

6 Slurries used for chemical-mechanical polishing may be divided into
7 three categories including silicon polish slurries, oxide polish slurries and
8 metals polish slurries. A silicon polish slurry is designed to polish and
9 planarize bare silicon wafers. The silicon polish slurry can include a
10 proportion of particles in a slurry typically with a range from 1-15
11 percent by weight.

12 An oxide polish slurry may be utilized for polishing and
13 planarization of a dielectric layer formed upon a semiconductor wafer.
14 Oxide polish slurries typically have a proportion of particles in the
15 slurry within a range of 1-15 percent by weight. Conductive layers
16 upon a semiconductor wafer may be polished and planarized using
17 chemical-mechanical polishing and a metals polish slurry. A proportion
18 of particles in a metals polish slurry may be within a range of 1-5
19 percent by weight.

20 It has been observed that slurries can undergo chemical changes
21 during polishing processes. Such changes can include composition
22 and pH, for example. Furthermore, polishing can produce stray
23 particles from the semiconductor wafer, pad material or elsewhere.
24 Polishing may be adversely affected once these by-products reach a

1 sufficient concentration. Thereafter, the slurry is typically removed from
2 the chemical-mechanical polishing processing tool.

3 It is important to know the status of a slurry being utilized to
4 process semiconductor wafers inasmuch as the performance of a
5 semiconductor processor is greatly impacted by the slurry. Such
6 information can indicate proper times for flushing or draining the
7 currently used slurry.

8 9 SUMMARY OF THE INVENTION

10 The present invention provides semiconductor processors, sensors,
11 semiconductor processing systems, semiconductor workpiece processing
12 methods, and turbidity monitoring methods.

13 According to one aspect of the invention, a semiconductor
14 processor is provided. The semiconductor processor includes a process
15 chamber and a supply connection configured to provide slurry to the
16 process chamber. A sensor is provided to monitor turbidity of the
17 slurry. One embodiment of the sensor is configured to emit
18 electromagnetic energy towards the supply connection providing the
19 slurry. The supply connection is one of transparent and translucent in
20 one embodiment. The sensor includes a receiver in the described
21 embodiment configured to receive at least some of the emitted
22 electromagnetic energy and to generate a signal indicative of turbidity
23 responsive to the received electromagnetic energy.
24

001240 16495560

1 In another arrangement, plural sensors are provided to monitor
2 the turbidity of a subject material, such as slurry, at different
3 corresponding positions. In addition, one or more sensors can be
4 provided to monitor turbidity of a subject material within a horizontally
5 oriented supply connection or container, a vertically oriented supply
6 connection or container, or supply connections or containers in other
7 orientations.

8 One sensor configuration of the invention provides a source
9 configured to emit electromagnetic energy towards the supply connection.
10 The sensor additionally includes plural receivers. One receiver is
11 positioned to receive electromagnetic energy passing through the subject
12 material and configured to output a feedback signal indicative of the
13 received electromagnetic energy. The source is configured to adjust the
14 intensity of emitted electromagnetic energy to provide a substantially
15 constant amount of electromagnetic energy at the receiver. Another
16 receiver is provided to monitor the emission of electromagnetic energy
17 from the source and provide a signal indicative of turbidity.

18 The invention also includes other aspects including methodical
19 aspects and other structural aspects as described below.
20

21 BRIEF DESCRIPTION OF THE DRAWINGS

22 Preferred embodiments of the invention are described below with
23 reference to the following accompanying drawings.
24

1 Fig. 1 is an illustrative representation of a slurry distributor and
2 semiconductor processor.

3 Fig. 2 is an illustrative representation of an exemplary
4 arrangement for monitoring a static slurry.

5 Fig. 3 is an illustrative representation of an exemplary
6 arrangement for monitoring a dynamic slurry.

7 Fig. 4 is an isometric view of one configuration of a turbidity
8 sensor.

9 Fig. 5 is a cross-sectional view of another sensor configuration.

10 Fig. 6 is an illustrative representation of an exemplary
11 arrangement of a source and receiver of a sensor.

12 Fig. 7 is a functional block diagram illustrating components of an
13 exemplary sensor and associated circuitry.

14 Fig. 8 is a schematic diagram of an exemplary sensor
15 configuration.

16 Fig. 9 is a schematic diagram illustrating circuitry of the sensor
17 configuration shown in Fig. 6.

18 Fig. 10 is a schematic diagram of another exemplary sensor
19 configuration.

20 Fig. 11 is an illustrative representation of a sensor implemented
21 in a centrifuge application.
22
23
24

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

This disclosure of the invention is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote the progress of science and useful arts" (Article 1, Section 8).

Referring to Fig. 1, a semiconductor processing system 10 is illustrated. The depicted semiconductor processing system 10 includes a semiconductor processor 12 coupled with a distributor 14. Semiconductor processor 12 includes a process chamber 16 configured to receive a semiconductor workpiece, such as a silicon wafer. In an exemplary configuration, semiconductor processor 12 is implemented as a chemical-mechanical polishing processing tool.

Distributor 14 is configured to supply a subject material for use in semiconductor workpiece processing operations. For example, distributor 14 can supply a subject material comprising a slurry to semiconductor processor 12 for chemical-mechanical polishing applications.

Exemplary conduits or piping of semiconductor processing system 10 are shown in Fig. 1. In the depicted configuration, a static route 18 and a dynamic route 20 are provided. Further details of static route 18 and dynamic route 20 are described below with reference to Figs. 2 and 3, respectively. In general, static route 18 is utilized to provide monitoring of the subject material of distributor 14 in a substantially static state. Such provides real-time information regarding the subject material being utilized within semiconductor processing system 10. Dynamic route 20 comprises a recirculation and distribution

1 line in one configuration. In addition, subject material can be supplied
2 to semiconductor processor 12 via dynamic route 20.

3 Distributor 14 can include an internal recirculation pump (not
4 shown) to periodically recirculate subject material through dynamic
5 route 20. Subject material having particulate matter, such as a slurry,
6 experiences gravity separation over time. Separation of such particulate
7 matter of the slurry is undesirable. For example, the particulate matter
8 may settle in areas of piping, valves or other areas of a supply line
9 which are difficult to reach and clean. Further, some particulate matter
10 may be extremely difficult to resuspend once it has settled over a
11 sufficient period of time. Accordingly, it is desirable to monitor
12 turbidity (percent solids within a liquid) of the subject material to
13 enable reduction or minimization of excessive settling.

14 Referring to Fig. 2, details of an exemplary static route 18
15 coupled with distributor 14 are illustrated. Static route 18 includes an
16 elongated tube or pipe 19 for receiving subject material from
17 distributor 14. In a preferred embodiment, pipe 19 comprises a
18 transparent or translucent material, such as a transparent or translucent
19 plastic. Static route 18 is coupled with distributor 14 at an intake
20 end 22 of pipe 19. Piping hardware provided within the depicted static
21 route 18 includes an intake valve 24, sensors 26 and an exhaust
22 valve 28. Exhaust valve 28 is adjacent an exhaust end 30 of static
23 route 18.
24

001240 1649560

Valves 24, 28 can be selectively controlled to provide monitoring of the subject material of distributor 14 in a substantially static state. For example, with exhaust valve 28 in a closed state, intake valve 24 may be selectively opened to permit the entry of subject material within an intermediate container 32. Container 32 can be defined as the portion of static route 18 intermediate intake valve 24 and exhaust valve 28 in the described configuration. In typical operations, intake valve 24 is sealed or closed following entry of subject material into container 32. In the depicted arrangement, static route 18 is provided in a substantially vertical orientation. Static route 18 using valves 24, 28 and container 32 is configured to provide received subject material in a substantially static state (e.g., the subject material is not in a flowing state).

Plural sensors 26 are provided at predefined positions relative to container 32 as shown. Sensors 26 are configured to monitor the opaqueness or turbidity of subject material received within static route 18. In one configuration, plural sensors 26 are provided at different vertical positions to provide monitoring of the turbidity of the subject material within container 32 at corresponding different desired vertical positions of container 32. Such can be utilized to provide differential information between the sensors 26 to indicate small changes in slurry settling.

As described in further detail below, individual sensors include a source 40 and a receiver 42. In one configuration, source 40 is

1 configured to emit electromagnetic energy towards container 32.
2 Receiver 42 is configured and positioned to receive at least some of the
3 electromagnetic energy. As described above, pipe 19 can comprise a
4 transparent or translucent material permitting passage of electromagnetic
5 energy. Sensors 26 can output signals indicative of the turbidity at the
6 corresponding vertical positions of container 32 responsive to sensing
7 operations.

8 It is desirable to provide plural sensors 26 in some configurations
9 to monitor settling of particulate material (precipitation rates) over time
10 within the subject material at plural vertical positions. Monitoring a
11 substantially static subject material provides numerous benefits. Utilizing
12 one or more sensors 26, the rate of separation can be monitored
13 providing information regarding the condition of the subject material or
14 slurry (e.g., testing and quantifying characteristics of a CMP slurry).

15 Properties of the subject material can be derived from the
16 monitoring including, for example, how well particulate matter is
17 suspended, adequate mixing, amount of or effectiveness of surfactant
18 additives, the approximate size of the particulate matter, agglomeration
19 of particulate matter, slurry age or lifetime, and likelihood of slurry
20 causing defects. Such monitoring of settling rates can indicate when to
21 change or drain a slurry being applied to semiconductor processor 12
22 to avoid degradation in processing performance, such as polishing
23 performance within a chemical-mechanical polishing processor.
24

001240" T643550

1 Subject material within container 32 may be drained via exhaust
2 valve 28 following monitoring of the subject material. Exhaust end 30
3 of static route 18 can be coupled with a recovery system for direction
4 back to distributor 14, or to a drain if the subject material will not be
5 reused.

6 Referring to Fig. 3, details of dynamic route 20 are described.
7 Dynamic route 20 comprises a recirculation pipe 50 coupled with a
8 supply connection 52. Recirculation pipe 50 and supply connection 52
9 preferably comprise transparent or translucent tubing or piping, such as
10 transparent or translucent plastic pipe.

11 Recirculation pipe 50 includes an intake end 54 and a discharge
12 end 56. Subject material or slurry can be pumped into recirculation
13 pipe 50 via intake end 54. An intake valve 58 and an exhaust or
14 discharge valve 60 are coupled with recirculation pipe 50 for controlling
15 the flow of subject material. Plural sensors 26 are provided within
16 sections of recirculation pipe 50 as shown. One of sensors 26 is
17 vertically arranged with respect to a vertical pipe section 62. Another
18 of sensors 26 is horizontally oriented with respect to a horizontal pipe
19 section 64. Sensors 26 are configured to monitor the turbidity of
20 subject material or slurry within vertical pipe section 62 and horizontal
21 pipe section 64.

22 Individual sensors 26 configured to monitor horizontal pipe sections
23 (e.g., pipe section 64) may be arranged to monitor a lower portion of
24 the horizontal pipe for gravity settling of particulate matter. As

1 described below, an optical axis of sensor 26 can be aimed to intersect
2 a lower portion of horizontally arranged tubing or piping to provide the
3 preferred monitoring. Such can assist with detection of precipitation of
4 particulate matter which can form into large undesirable particles leading
5 to defects. Accordingly, once a turbidity limit has been reached, the
6 tubing or piping may be flushed.

7 Supply connection 52 is in fluid communication with horizontal
8 pipe section 64. In addition, supply connection 52 is in fluid
9 communication with process chamber 16 of semiconductor processor 12
10 shown in Fig. 1. Supply connection 52 is configured to supply subject
11 material such as slurry to process chamber 16. A sensor 26 is
12 provided adjacent supply connection 52. Sensor 26 is configured to
13 monitor the turbidity of subject material within supply connection 52.
14 Additionally, a supply valve 66 controls the flow of subject material
15 within supply connection 52.

16 Although only one supply connection 52 is illustrated, it is
17 understood that additional supply connections can be provided to couple
18 associated semiconductor processors (not shown) with recirculation
19 pipe 50 and distributor 14. The depicted supply connection 52 is
20 arranged in a vertical orientation. Supply connection 52 with associated
21 sensor 26 may also be provided in a horizontal or other orientation in
22 other configurations.

23 Referring to Fig. 4, an exemplary configuration of sensor 26 is
24 shown. The illustrated configuration of sensor 26 includes a housing 70,

001240 1643550

1 cover 72 and associated circuit board 74. The illustrated housing 70
2 is configured to couple with a conduit, such as supply connection 52.
3 For example, housing 70 is arranged to receive supply connection 52
4 with a longitudinal orifice 76. Cover 72 is provided to substantially
5 enclose supply connection 52. In a preferred arrangement, housing 70
6 and cover 72 are formed of a substantially opaque material.

7 Housing 70 is configured to provide source 40 and receiver 42
8 adjacent supply connection 52. More specifically, housing 70 is
9 configured to align source 40 and receiver 42 with respect to supply
10 connection 52 and any subject material such as slurry therein. In the
11 depicted configuration, housing 70 aligns source 40 and receiver 42 to
12 define an optical axis 45 which passes through supply connection 52.

13 The illustrated housing 70 is configured to allow attachment of
14 sensor 26 to supply connection 52 or detachment of sensor 26 from
15 supply connection 52 without disruption of the flow of subject material
16 within supply connection 52. Housing 70 can be clipped onto supply
17 connection 52 as illustrated or removed therefrom without disrupting the
18 flow of subject material within supply connection 52 in the described
19 embodiment.

20 Source 40 and receiver 42 may be coupled with circuit board 74
21 via internal connections (not shown). Further details regarding circuitry
22 implemented within circuit board 74 are described below. The depicted
23 sensor configuration provides sensor 26 capable of monitoring the
24 turbidity of subject material within supply connection 52 without

1 contacting and possibly contaminating the subject material or without
2 disrupting the flow of subject material within supply connection 52.

3 More specifically, sensor 26 is substantially insulated from the
4 subject material within supply connection 52 in the described
5 arrangement. Accordingly, sensor 26 provides a non-intrusive device for
6 monitoring the turbidity of subject material 80. Such is preferred in
7 applications wherein contamination of subject material 80 is a concern.
8 Utilization of sensor 26 does not impede or otherwise affect flow of the
9 subject material.

10 In one configuration, source 40 comprises a light emitting
11 diode (LED) configured to emit infrared electromagnetic energy.
12 Source 40 is configured to emit electromagnetic energy of another
13 wavelength in an alternative embodiment. Receiver 42 may be
14 implemented as a photodiode in an exemplary embodiment.
15 Receiver 42 is configured to receive electromagnetic energy emitted from
16 source 40. Receiver 42 of sensor 26 is configured to generate a signal
17 indicative of the turbidity of the subject material and output the signal
18 to associated circuitry for processing or data logging.

19 Referring to Fig. 5, source 40 and receiver 42 are coupled with
20 electrical circuitry 78. In the illustrated embodiment, source 40 and
21 receiver 42 are aimed towards one another. Source 40 is operable to
22 emit electromagnetic energy 79 towards subject material 80. Particulate
23 matter within subject material 80 operates to absorb some of the
24 emitted electromagnetic energy 79. Accordingly, only a portion,

1 indicated by reference 82, of the emitted electromagnetic energy 79
2 passes through subject material 80 and is received within receiver 42.

3 Electrical circuitry 78 is configured to control the emission of
4 electromagnetic energy 79 from source 40 in the described configuration.
5 Receiver 42 is configured to output a signal indicative of the received
6 electromagnetic energy 82 corresponding to the intensity of the received
7 electromagnetic energy. Electrical circuitry 78 receives the outputted
8 signal and, in one embodiment, conditions the signal for application to
9 an associated computer 84. In one embodiment, computer 84 is
10 configured to compile a log of received information from receiver 42
11 of sensor 26.

12 Referring to Fig. 6, an alternative sensor arrangement indicated
13 by reference 26a is shown. In the depicted embodiment, an alternative
14 housing 70a is implemented as a cross fitting 44 utilized to align the
15 source and receiver of sensor 26a with supply connection 52. Supply
16 connection 52 is aligned along one axis of cross fitting 44.

17 In the depicted configuration, light-carrying cable or light pipe,
18 such as fiberoptic cable, is utilized to couple a remotely located source
19 and receiver with supply connection 52. A first fiberoptic cable 46
20 provides electromagnetic energy emitted from source 42 to supply
21 connection 52. A lens 47 is provided flush against supply
22 connection 52 and is configured to emit the electromagnetic light energy
23 from cable 46 towards supply connection 52 along optical axis 45
24 perpendicular to the axis of supply connection 52. Electromagnetic

1 energy which is not absorbed by subject material 80 is received within
2 a lens 49 coupled with a second fiberoptic cable 48. Fiberoptic
3 cable 48 transfers the received light energy to receiver 42. Sensor
4 arrangement 26a can include appropriate seals, bushings, etc., although
5 such is not shown in Fig. 6.

6 As previously mentioned, supply connection 52 is preferably
7 transparent to pass as much electromagnetic light energy as possible.
8 Supply connection 52 is translucent in an alternative arrangement.
9 Lenses 47, 49 are preferably associated with supply connection 52 to
10 provide maximum transfer of electromagnetic energy. In other
11 embodiments, lenses 47, 49 are omitted. Further alternatively, the
12 source and receiver of sensor 26 may be positioned within housing 70a
13 in place of lenses 47, 49. Fiberoptic cables 46, 48 could be removed
14 in such an embodiment.

15 Referring to Fig. 7, another implementation of sensor 26 is shown.
16 Source 40 and receiver 42 are arranged at a substantially 90° angle in
17 the depicted configuration. Source 40 operates to emit electromagnetic
18 energy 79 into supply connection 52 and subject material 80 within
19 supply connection 52. As previously stated, subject material 80 can
20 contain particulate matter which may operate to reflect light.
21 Receiver 42 is positioned in the depicted arrangement to receive such
22 reflected light 82a. Associated electrical circuitry coupled with
23 source 40 and receiver 42 can be calibrated to provide accurate
24 turbidity information responsive to the reception of reflected light 82a.

1 Although source 40 and receiver 42 are illustrated at a 90° angle in
2 the depicted arrangement, source 40 and receiver 42 may be arranged
3 at any other angular relationship with respect to one another and
4 supply connection 52 to provide emission of electromagnetic energy 79
5 and reception of reflected electromagnetic energy 82a.

6 Referring to Fig. 8, one arrangement of sensor 26 for providing
7 turbidity information of subject material 80 is shown. Source 40 is
8 implemented as a light emitting diode (LED) configured to emit infrared
9 electromagnetic energy 79 towards supply connection 52 having subject
10 material 80 in the depicted arrangement. A positive voltage bias may
11 be applied to a voltage regulator 86 configured to output a constant
12 supply voltage. For example, the positive voltage bias can be a 12
13 Volt DC voltage bias and voltage regulator 86 can be configured to
14 provide a 5 Volt DC reference voltage to light emitting diode
15 source 40.

16 Source 40 emits electromagnetic energy of a known intensity
17 responsive to an applied current from dropping resistor 87.
18 Receiver 42 comprises a photodiode in an exemplary embodiment
19 configured to receive light electromagnetic energy 82 not absorbed within
20 subject material 80. Photodiode receiver 42 is coupled with an
21 amplifier 88 in the depicted configuration. Amplifier 88 is configured
22 to provide an amplified output signal indicating the turbidity of subject
23 material 80. Other configurations of source 40 and receiver 42 are
24 possible.

Referring to Fig. 9, additional details of the arrangement shown in Fig. 8 are illustrated. Source 40 is implemented as a light emitting diode (LED). Receiver 42 comprises a photodiode. A potentiometer 90 is coupled with a pin 1 and a pin 8 of amplifier 88 and can be varied to provide adjustment of the gain of amplifier 88. An exemplary variable base resistance of potentiometer 90 is 100 Ω k.

Another potentiometer 92 is coupled with a pin 5 of amplifier 88 and is configured to provide calibration of sensor 26. Potentiometer 92 may be varied to provide an offset of the output reference of amplifier 88. An exemplary variable base resistance of potentiometer 92 is 500 Ω .

A positive voltage reference bias is applied to a diode 94. An exemplary positive voltage is approximately 12-24 Volts DC. Voltage regulator 86 receives the input voltage and provides a reference voltage of 5 Volts DC in the described embodiment.

Referring to Fig. 10, an alternative sensor configuration is illustrated as reference 26b. The illustrated sensor configuration includes a driver 95 coupled with source 40. Additionally, a beam splitter 96 is provided intermediate source 40 and supply connection 52. Further, an additional receiver 43 and associated amplifier 97 are provided as illustrated.

A reference voltage is applied to driver 95 during operation. Source 40 is operable to emit electromagnetic energy 79 towards beam splitter 96. Beam splitter 96 directs received electromagnetic energy

1 into a beam 91 towards supply connection 52 and a beam 93 towards
2 receiver 43. Receiver 42 is positioned to receive non-absorbed
3 electromagnetic energy 91 passing through supply connection 52 and
4 subject material 80. Receiver 42 is configured to generate and output
5 a feedback signal to driver 95. The feedback signal is indicative of the
6 electromagnetic energy 91 received within receiver 42.

7 The depicted sensor 26b is configured to provide a substantially
8 constant amount of light electromagnetic energy to receiver 42.
9 Driver 95 is configured to control the amount or intensity of emitted
10 electromagnetic energy from source 40. More specifically, driver 95 is
11 configured in the described embodiment to increase or decrease the
12 amount of electromagnetic energy 79 emitted from source 40 responsive
13 to the feedback signal from receiver 42.

14 Receiver 43 is positioned to receive the emitted electromagnetic
15 energy directed from beam splitter 96 along beam 93. Receiver 43
16 receives electromagnetic energy not passing through subject material 80
17 in the depicted embodiment. The output of receiver 43 is applied to
18 amplifier 97 which provides a signal indicative of the turbidity of subject
19 material 80 within supply connection 52 responsive to the intensity of
20 electromagnetic energy of beam 93.

21 Referring to Fig. 11, an exemplary alternative configuration for
22 analyzing slurry in a substantially static state is shown. The illustrated
23 static route 18a comprises a centrifuge 100. The depicted
24 centrifuge 100 includes a container 102 configured to receive subject

material 80. Plural sensors 26 are provided at predefined positions along container 102 to monitor the turbidity of subject material 80 at different radial positions. Centrifuge 100 including container 102 is configured to rapidly rotate in the direction indicated by arrows 104 about axis 101 to assist with precipitation of particulate matter within subject material 80. Such provides increased settling rates of the particulate matter. Sensors 26 can individually provide turbidity information of subject material 80 at the predefined positions of sensors 26 relative to container 102. Such information can indicate the state or condition of the slurry as previously discussed. Centrifuge 100 can be configured to receive samples of slurry or other subject material during operation of semiconductor workpiece system 10. Information from sensors 26 can be accessed via rotary couplings or wireless configurations during rotation of container 102 in exemplary embodiments.

From the foregoing, it is apparent the present invention provides a sensor which can be utilized to monitor turbidity of a nearly opaque fluid. Further, the disclosed sensor configurations have a wide dynamic range, are nonintrusive and have no wetted parts. In addition, the sensors of the present invention are cost effective when compared with other devices, such as densitometers.

In compliance with the statute, the invention has been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the invention is not

1 limited to the specific features shown and described, since the means
2 herein disclosed comprise preferred forms of putting the invention into
3 effect. The invention is, therefore, claimed in any of its forms or
4 modifications within the proper scope of the appended claims
5 appropriately interpreted in accordance with the doctrine of equivalents.
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

007240 76495560

1 CLAIMS:

2 1. A semiconductor processor comprising:

3 a process chamber configured to receive a semiconductor
4 workpiece for processing;

5 a supply connection in fluid communication with the process
6 chamber and configured to supply slurry to the process chamber; and

7 a sensor configured to monitor the turbidity of the slurry.

8
9 2. The semiconductor processor according to claim 1 wherein
10 the supply connection is arranged in a substantially horizontal
11 orientation.

12
13 3. The semiconductor processor according to claim 1 wherein
14 the supply connection is arranged in a substantially vertical orientation.

15
16 4. The semiconductor processor according to claim 1 wherein
17 the sensor is configured to attach to the supply connection and detach
18 from the supply connection without disruption of the supply of slurry
19 within the supply connection.

20
21 5. The semiconductor processor according to claim 1 wherein
22 the sensor is configured to emit electromagnetic energy towards the
23 supply connection and to receive at least some of the electromagnetic
24 energy from the supply connection.

6. The semiconductor processor according to claim 5 wherein the sensor is configured to receive reflected electromagnetic energy from the supply connection.

7. The semiconductor processor according to claim 1 wherein the sensor is configured to generate a signal indicative of the turbidity of the slurry responsive to the received electromagnetic energy.

8. The semiconductor processor according to claim 1 wherein the sensor is substantially insulated from the slurry.

9. The semiconductor processor according to claim 1 wherein the process chamber comprises a chemical-mechanical polishing chamber.

10. A sensor comprising:

a source configured to emit electromagnetic energy towards a subject material;

an initial receiver configured to receive at least some of the electromagnetic energy, the initial receiver being configured to generate a signal indicative of the turbidity of the subject material and responsive to the received electromagnetic energy; and

a housing configured to align the source and initial receiver with respect to the subject material.

11. The sensor according to claim 10 wherein the source comprises a light emitting diode.

12. The sensor according to claim 11 wherein the light emitting diode is configured to emit infrared electromagnetic energy.

13. The sensor according to claim 10 further comprising:
another receiver configured to receive at least some of the electromagnetic energy passing through the subject material and to generate a signal indicative of the received electromagnetic energy; and
a driver configured to control the amount of emitted electromagnetic energy from the source to provide a substantially constant amount of received electromagnetic energy at the another receiver.

14. The sensor according to claim 10 wherein the initial receiver is configured to receive emitted electromagnetic energy emitted without passage of the electromagnetic energy through the subject material.

15. The sensor according to claim 14 further comprising a beam splitter configured to direct electromagnetic energy from the source to the subject material and to the initial receiver.

16. The sensor according to claim 10 wherein the initial receiver is configured to receive emitted electromagnetic energy passed through the subject material.

17. The sensor according to claim 10 wherein the sensor is configured to receive reflected electromagnetic energy from the subject material.

18. The sensor according to claim 10 wherein the housing is configured to attach to a supply connection containing the subject material and detach from the supply connection without disruption of the flow of subject material within the supply connection.

19. An apparatus comprising:

a container configured to provide a subject material in a substantially static state; and

at least one sensor provided at a predefined position relative to the container to monitor the turbidity of the subject material at a desired vertical position of the container.

1 20. The apparatus according to claim 19 wherein the at least
2 one sensor comprises a plurality of sensors provided at different
3 predefined positions relative to the container to monitor the turbidity
4 of the subject material at a plurality of desired vertical positions of the
5 container.

6
7 21. The apparatus according to claim 19 wherein the at least
8 one sensor comprises:

9 a source configured to emit electromagnetic energy towards the
10 container; and

11 a receiver configured to receive at least some of the
12 electromagnetic energy.

13
14 22. A semiconductor processor comprising:

15 a process chamber configured to receive and process a
16 semiconductor workpiece;

17 a connection provided in fluid communication with the process
18 chamber and configured to supply slurry to the process chamber; and

19 a sensor configured to monitor the turbidity of the slurry and
20 including:

21 a source configured to emit electromagnetic energy towards
22 the connection; and

23 a receiver configured to receive at least some of the
24 electromagnetic energy.

1 23. The semiconductor processor according to claim 22 wherein
2 the connection is arranged in a substantially horizontal orientation.

3
4 24. The semiconductor processor according to claim 22 wherein
5 the connection is arranged in a substantially vertical orientation.

6
7 25. The semiconductor processor according to claim 22 wherein
8 the sensor is configured to generate a signal indicative of the turbidity
9 responsive to the received electromagnetic energy.

10
11 26. The semiconductor processor according to claim 22 wherein
12 the sensor is substantially insulated from the slurry.

13
14 27. The semiconductor processor according to claim 22 further
15 comprising a housing coupled with the connection and configured to
16 align the source and the receiver with respect to the connection.

17
18 28. The semiconductor processor according to claim 22 wherein
19 the process chamber comprises a chemical-mechanical polishing chamber.

20
21 29. The semiconductor processor according to claim 22 wherein
22 the connection is transparent.

1 30. The semiconductor processor according to claim 22 wherein
2 the connection is translucent.

3
4 31. A semiconductor processor system comprising:
5 a distributor configured to supply a slurry;
6 a process chamber configured to receive and process a
7 semiconductor workpiece;
8 a connection configured to supply slurry from the distributor to
9 the process chamber; and
10 a sensor configured to monitor the turbidity of the slurry and
11 including:
12 a source configured to emit electromagnetic energy towards
13 the connection; and
14 a receiver configured to receive at least some of the
15 electromagnetic energy.

16
17 32. The semiconductor processor system according to claim 31
18 wherein the sensor is substantially insulated from the slurry.

19
20 33. The semiconductor processor system according to claim 31
21 wherein the process chamber comprises a chemical-mechanical polishing
22 chamber.
23
24

1 34. The semiconductor processor system according to claim 31
2 wherein the connection is transparent.

3
4 35. The semiconductor processor system according to claim 31
5 wherein the connection is translucent.

6
7 36. A semiconductor workpiece processing method comprising:
8 providing a semiconductor process chamber;
9 supplying slurry to the semiconductor process chamber; and
10 monitoring the turbidity of the slurry using a sensor.

11
12 37. The method according to claim 36 wherein the supplying
13 comprises using a supply connection and the monitoring comprises
14 monitoring slurry within the supply connection.

15
16 38. The method according to claim 37 further comprising
17 coupling the sensor with the supply connection.

18
19 39. The method according to claim 36 wherein the monitoring
20 comprises:

21 emitting electromagnetic energy towards the slurry; and
22 receiving at least some of the electromagnetic energy.
23
24

1 40. The method according to claim 36 further comprising
2 generating a signal indicative of the turbidity after the monitoring.

3
4 41. The method according to claim 36 further comprising
5 insulating the slurry from the sensor.

6
7 42. The method according to claim 36 wherein the providing
8 comprises providing a chemical-mechanical polishing process chamber.

9
10 43. A turbidity monitoring method comprising:
11 providing a source;
12 emitting electromagnetic energy towards subject material using the
13 source;
14 aligning an initial receiver relative to the subject material;
15 receiving at least some of the electromagnetic energy after the
16 emitting using the initial receiver; and
17 generating a signal indicative of the turbidity after the receiving.

18
19 44. The method according to claim 43 wherein the emitting
20 comprises emitting infrared electromagnetic energy.

007270 1645560

1 49. A turbidity monitoring method comprising:
2 providing a container;
3 providing subject material in a substantially static condition within
4 the container;
5 monitoring the turbidity of the subject material at a predefined
6 vertical position within the container; and
7 generating a signal indicative of the turbidity of the subject
8 material after the monitoring.

9
10 50. The method according to claim 49 further comprising
11 monitoring the turbidity of the subject material at another predefined
12 vertical position within the container.

13
14 51. The method according to claim 49 wherein the monitoring
15 comprises:
16 emitting electromagnetic energy towards the subject material; and
17 receiving at least some of the electromagnetic energy.

18
19 52. The method according to claim 49 further comprising
20 rotating the subject material during the monitoring.

007240-1649560

1 53. A semiconductor workpiece processing method comprising:
2 providing a semiconductor processor having a process chamber
3 configured to receive a semiconductor workpiece;
4 supplying slurry to the process chamber using a connection;
5 emitting electromagnetic energy towards the connection using a
6 sensor;
7 receiving at least some of the electromagnetic energy using the
8 sensor; and
9 generating a signal indicative of turbidity of the slurry responsive
10 to the receiving.

11
12 54. The method according to claim 53 wherein the emitting
13 comprises emitting infrared electromagnetic energy.

14
15 55. The method according to claim 53 further comprising
16 substantially insulating the slurry from the sensor.

17
18 56. The method according to claim 53 wherein the providing
19 comprises providing chemical-mechanical polishing semiconductor
20 processor.

21
22 57. The method according to claim 53 further comprising
23 attaching the sensor to the connection and detaching the sensor from
24 the connection while maintaining the supplying.

58. A semiconductor workpiece processing method comprising:
providing a semiconductor processor having a process chamber
configured to receive a semiconductor workpiece;
supplying slurry to the process chamber using a connection;
emitting infrared electromagnetic energy using a source;
splitting the infrared electromagnetic energy to direct some of the
infrared electromagnetic energy towards the connection;
first receiving at least some of the infrared electromagnetic energy
passing through the connection using a first receiver;
generating a feedback signal using the first receiver responsive to
the first receiving;
adjusting the emitting via the source responsive to the feedback
signal to provide a substantially constant amount of electromagnetic
energy to the first receiver;
second receiving at least some of the infrared electromagnetic
energy not passing through the connection using a second receiver; and
generating a signal indicative of turbidity of the slurry using the
second receiver responsive to the second receiving.

1 ABSTRACT OF THE DISCLOSURE

2 Semiconductor processors, sensors, semiconductor processing
3 systems, semiconductor workpiece processing methods, and turbidity
4 monitoring methods are provided. According to one aspect, a
5 semiconductor processor includes a process chamber configured to
6 receive a semiconductor workpiece for processing; a supply connection
7 in fluid communication with the process chamber and configured to
8 supply slurry to the process chamber; and a sensor configured to
9 monitor the turbidity of the slurry. Another aspect provides a
10 semiconductor workpiece processing method including providing a
11 semiconductor process chamber; supplying slurry to the semiconductor
12 process chamber; and monitoring the turbidity of the slurry using a
13 sensor.

14
15
16
17
18
19
20
21
22
23
24

EL46568 2905

1/6

AS FILED

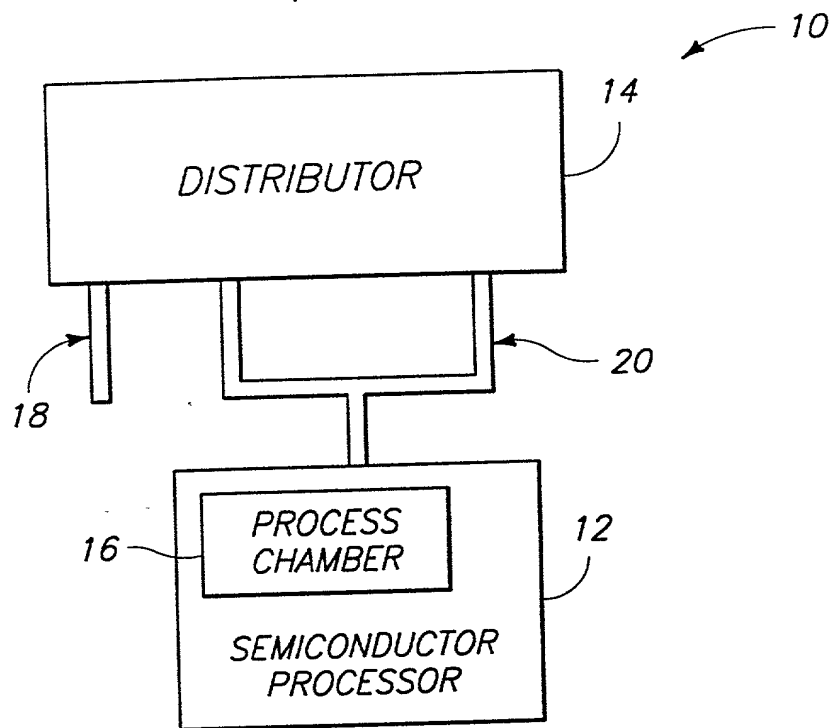


Fig. 1

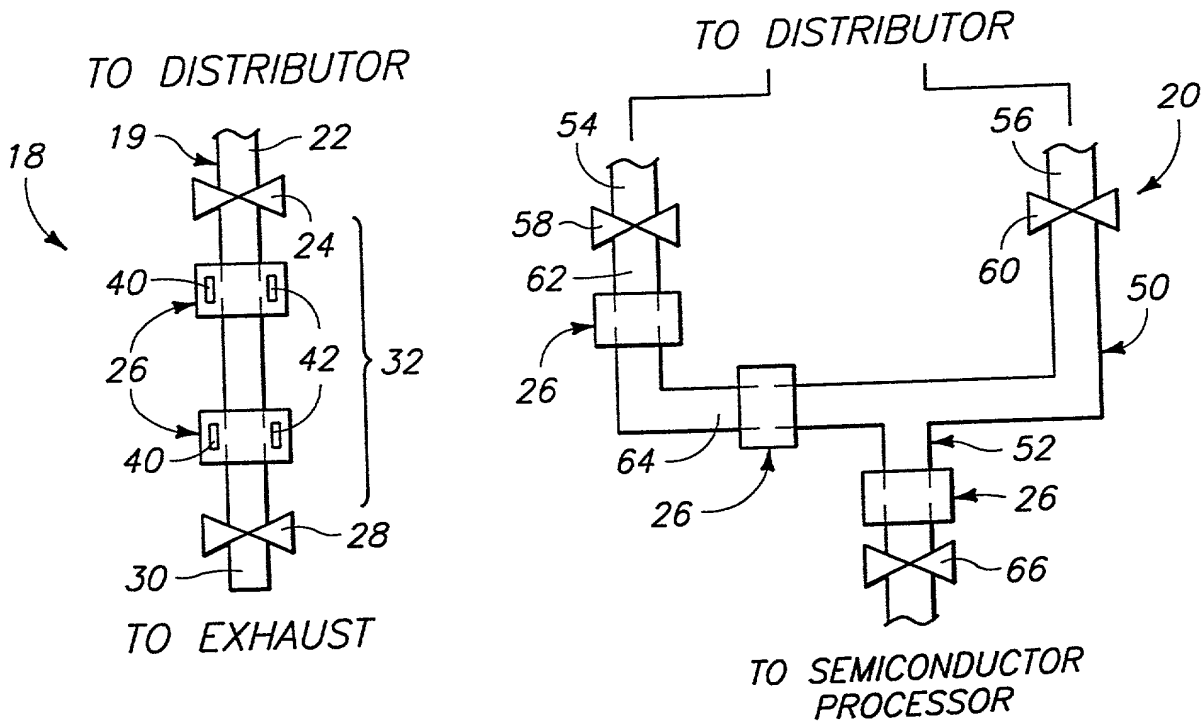


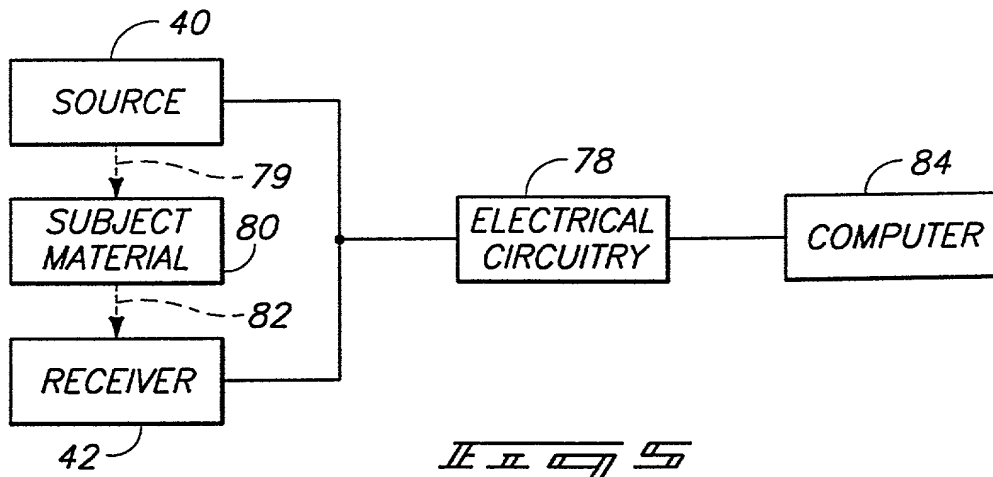
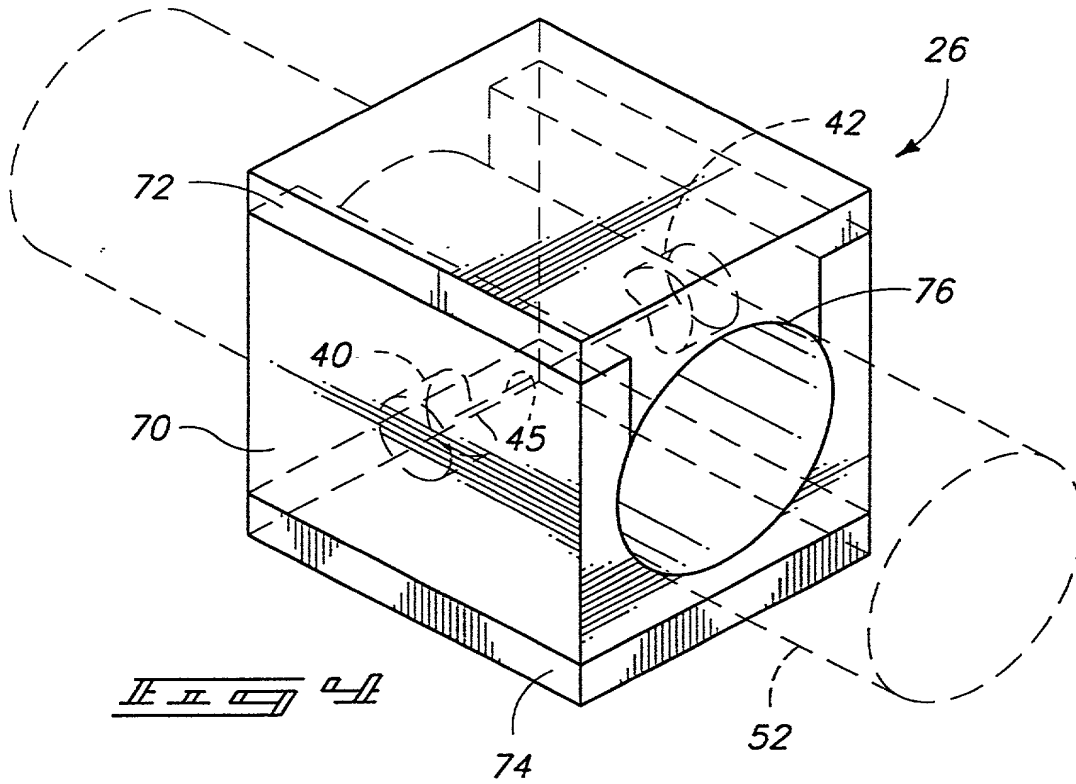
Fig. 2

TO SEMICONDUCTOR PROCESSOR

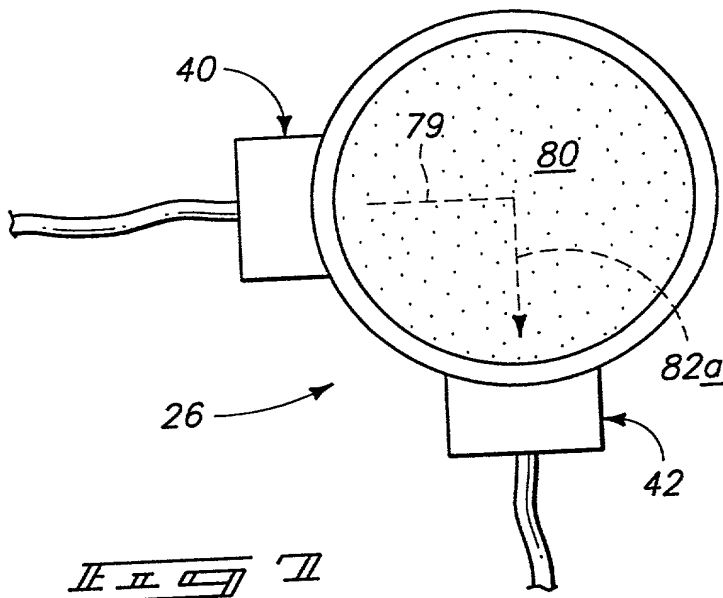
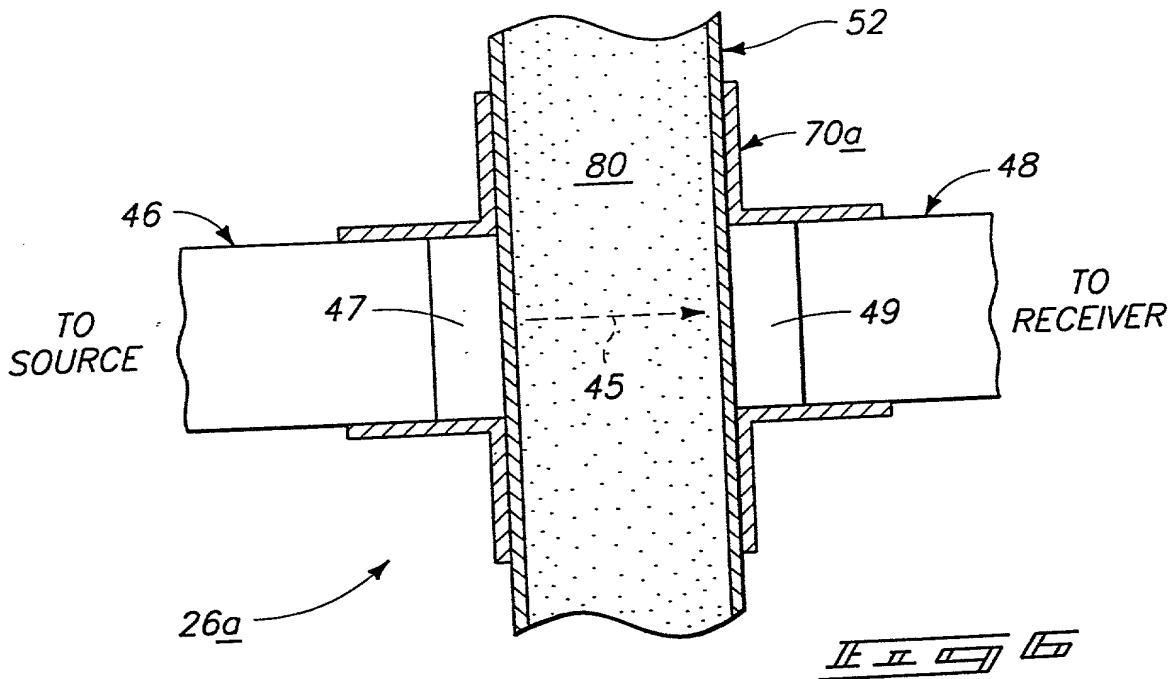
Fig. 3

AS FILED

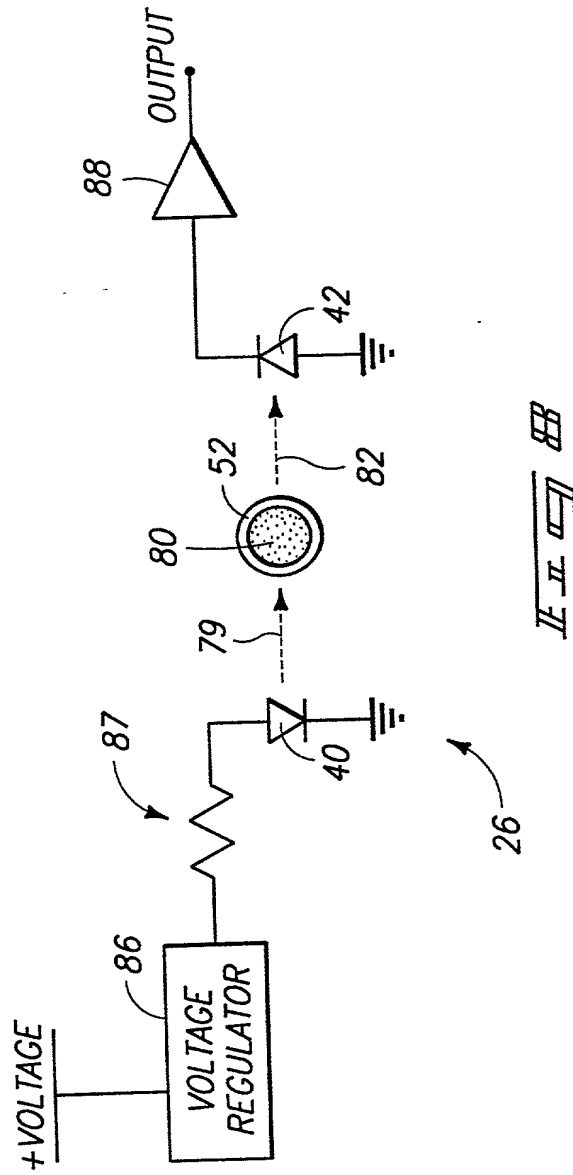
2/6



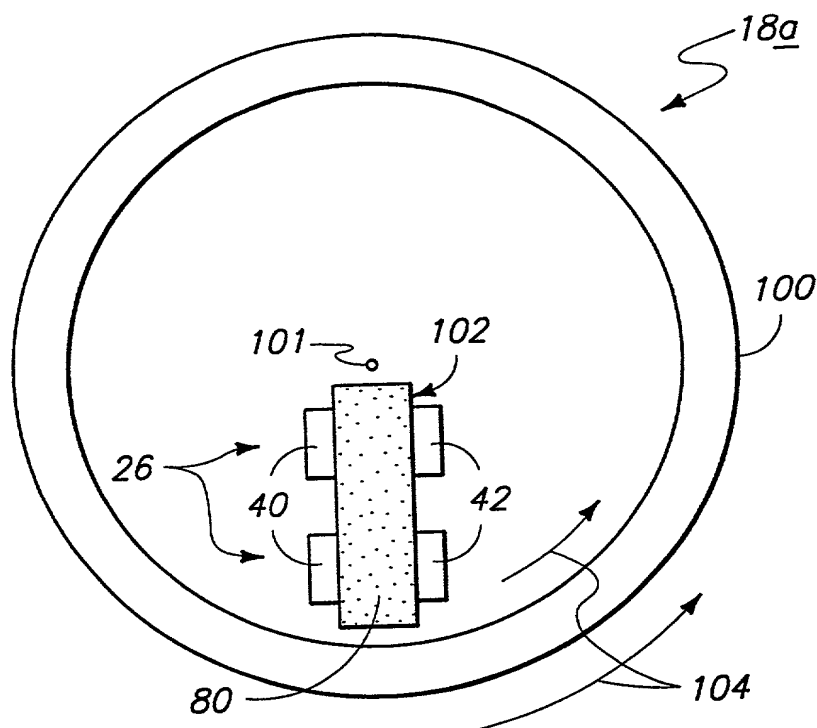
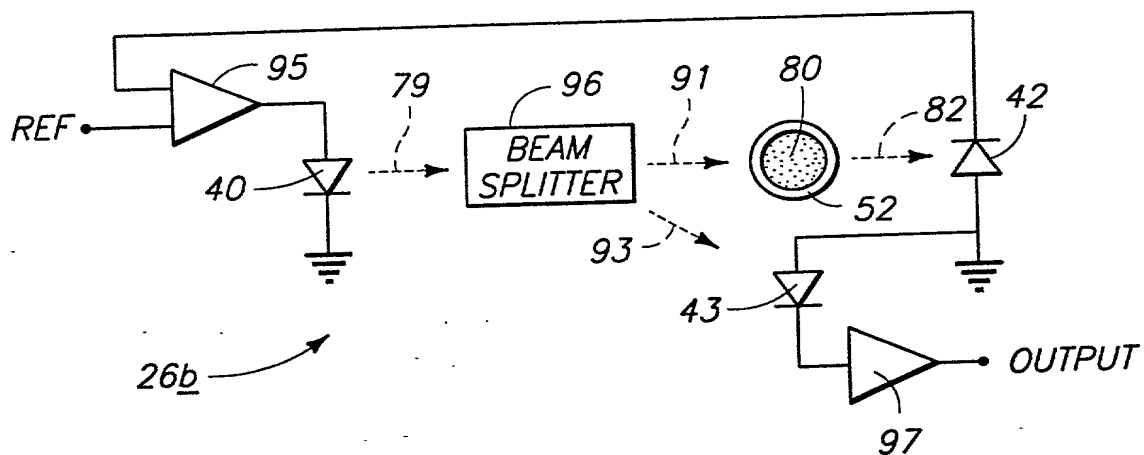
3/6

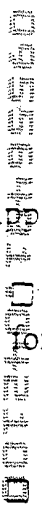


001240 16435560



6/6



[illegible]

SECRET

SECRET

[illegible]

B